Scheduling, managing and controlling design in the construction project process

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1. Summary

"Account is rarely taken when planning projects of the interdisciplinary, iterative nature of the design process." [1]. The paper which opened with this statement (published in 2000) introduced a new planning methodology called the 'analytical design planning technique' (ADePT), which was developed to plan and manage iterative processes such as design and to identify risk and manage change.

Despite the promise of ADePT, the potential has taken time to be realised. The combined forces of technology limitations, time pressures within projects, and reluctance to change within the industry meant that during 2001 to 2005 uptake of the approach was slow. However, over the last 24 months the investment in educating the industry as to the frailties of traditional approaches has lead to accelerated uptake and adoption of the ADePT methodology. Over this period the approach has been implemented on over 30 projects worldwide, with a total contract value of over £10Bn, ranging from a £6M building fit-out project to a £2Bn urban redevelopment project. A number of practices have also been established to ensure design planning and control is undertaken in an effective manner.



This paper reports the evolution of the approach, key learning from these projects, including the findings of an independent review which highlights a number of areas where benefit is derived and shows a significant return on the investment, both human and financial, required to implement the technique.

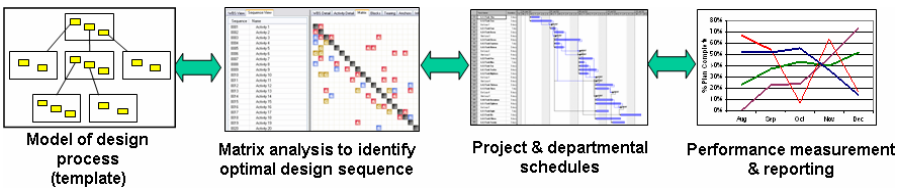
2. Background

For over 10 years the separation of design from the rest of the project process has been recognised as a fundamental weakness in the construction industry. Since then, steps have been taken by the industry to better integrate the design stages of projects within the broader project. This has, in part, been driven by wider usage of design-build contracts but also by a growing awareness of the complex interaction between design and construction. However, the latest figures published by the UK Government[2] show that the design goes over budget in a third of projects and is delivered late over 40% of the time, with the knock-on effect that only 44% of construction processes are delivered within budget and only 60% are on time. Clearly there is more to do. The ongoing failure to deliver consistently the design stage of projects efficiently and effectively is partly due to an inability to identify and plan the iteration which is inherent within the process.

The ADePT methodology as described in the paper referred to above in 2000 was a planning approach. The development of a design schedule integrated across the design disciplines, incorporating iteration, and linked to procurement and construction sets a framework for project delivery. Since then it has been implemented on around 30 projects. Unsurprisingly, we have seen that the number of unpredictable variables in a design and construction project means that it is usually impossible to rigidly follow the original schedule and that the actual design process can deviate wildly from the schedule. As a result, the ADePT methodology now incorporates an approach to controlling the design process to ensure that deviation is minimised.

3. The Principles

The ADePT methodology has evolved to comprise the four stages. In the first stage, the scope of the design process and dependencies between activities are defined. In the second, the sequence of the process is determined based on the dependencies between activities and the iteration within the process. The third stage entails the representation of the



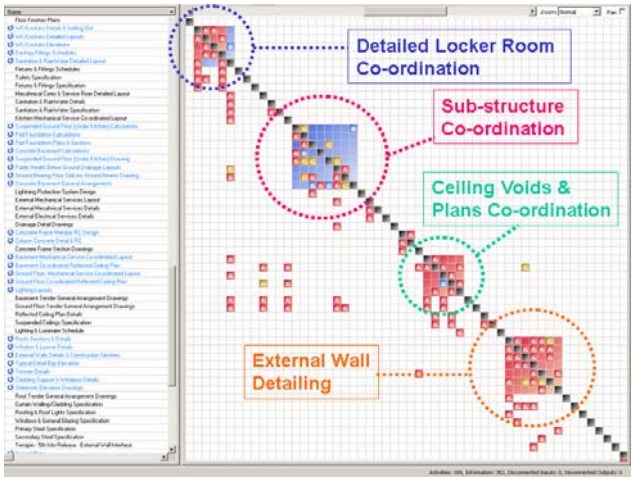
design process in the form of a schedule, enabling the integration of the design process with procurement and construction. It is in the new fourth stage where the design process is monitored and the flow of work is controlled.

3.1 Defining the Scope of the Design Process

Clearly to define the full scope of a design project in terms of the activities required and the dependencies between them is a time-consuming process. In 2000 we stated that it had been possible to define the design process generically, with over 90% of a project's activities pre-defined. In fact, the term 'generic' is somewhat misleading in that we now hold a data-library that is being expanded continuously as more projects are planned and, consequently, more parts of the process (which had previously been undefined) are added, giving coverage well beyond 90%.

3.2 Process Sequencing

A matrix approach to sequencing the design process is used. A sequence of activities is calculated which minimises the iteration in the design process and ensures any assumptions which the team need to make are ones which can be made with confidence. This is achieved by weighting the dependencies between activities on a three-point scale. The calculation of a sequence, including clusters of inter-related tasks, prioritises the availability of outputs associated with the most critical dependencies.



The interdependent, iterative groups of activities which remain in the process following sequencing are typically multi-disciplinary. They represent points in the design process where design team members should work concurrently to solve the interdependent problem. Usually they also represent elements of the construction, and therefore of the design output, which require co-ordination.

3.3 Scheduling

The sequenced design process must be represented in a schedule so that design delivery dates can be seen alongside construction and procurement target dates. The optimised process is usually imported into the project management tool which the project's Planner is using to maintain the construction schedule.

3.4 Controlling the Design Workflow

All too often deviation from the agreed design schedule means that very quickly it does not really represent the design process being undertaken. It is then close to impossible to implement action to get the process back to the target schedule and the deviation increases to the point where the schedule is meaningless. Our experience is that many conventionally planned projects suffer from this problem which contributes to the general lack of confidence in design schedules. Therefore, having produced a target design schedule, the design process needs to be controlled. ADePT incorporates an approach to process control, based on Lean Production methods[3], which pre-empts deviation from the target schedule by analysing constraints, which then allows the schedule to be kept up-to-date and used in meaningful way with potential risks to the project being mitigated in advance.

4. Practical Implementation

4.1 A Facilitated Approach to Planning

Often, very little time is dedicated to planning the design stages of a project. This is in part due to the shortage of knowledge about the design process within any single organisation or individual involved but also because design teams sometimes get insufficient notice of contract award and, therefore, are hurried into design production without adequate set-up time. These problems can be overcome by involving all design disciplines in the planning process so that their combined knowledge is captured, and by planning the planning process itself so that it happens quickly after contract award (or preferably before it). This suggests a facilitated approach to design planning.

Project applications of ADePT have demonstrated that the use of a facilitator, such as the Design Manager - to define the high level structure of a design plan, involve the design team members at appropriate times in defining the design scope, and identify issues around the interfaces between design, procurement and construction - enables a consistent and meaningful schedule to be produced. The facilitator's role is a skilled one: unfortunately they cannot expect that all team members are going to recognise the benefit in

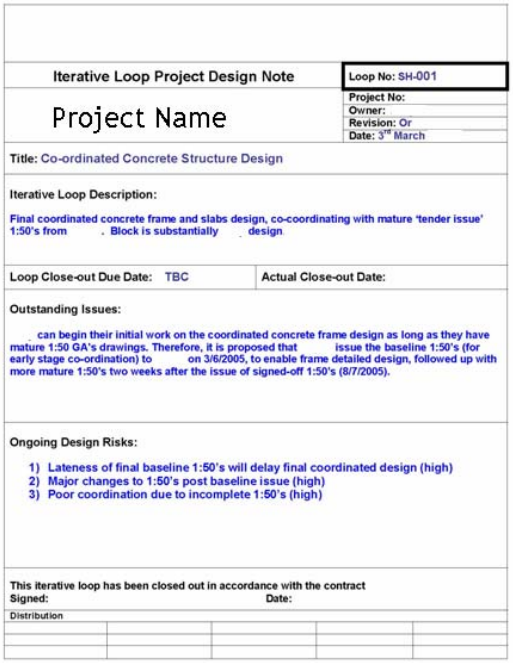
contributing to the design planning process or even in the need for a design schedule. The facilitator will ideally have a balanced understanding of the project itself, the design process generally, and planning, as well as the ability to foster positive and collaborative contributions from team members.

We have seen that a facilitator from outside the project team can be effective as long as they overcome their shortage in knowledge about the project at the outset. This can be done by undertaking a short workshop with the team to identify characteristics of the project and design risks. Feedback has shown that most team members benefit greatly from this type of activity: contrary to popular belief the team members do not often share the same understanding of the project scope and priorities around design decisions, and this workshop can help to deliver this shared understanding.

At the point where the facilitator involves the design team members to agree the precise scope of their responsibilities, it is imperative to focus on their requirements (which are largely information which is needed to progress the design) rather than their deliverables. One of the underpinning principles of ADePT is that the combined requirements of all dictate the optimal design sequence.

4.2 Dealing with Iteration

The approach identifies iteration within the design process. This in turn must be represented on a schedule. Usually this is achieved by grouping activities together in the schedule and running them concurrently over a period of time which is deemed necessary to develop a co-ordinated design solution, thus representing the concurrent, cross-disciplinary working that is needed to develop the co-ordinated outputs from the interdependent activities.



Iterative Loop Project Design Note	Loop No: SH-001
Project Name	Project No: Owner: Revision: Or Date: 3rd March

Title: Co-ordinated Concrete Structure Design

Iterative Loop Description:

Final coordinated concrete frame and slabs design, co-coordinating with mature 'tender issue' 1:50's from . Block is substantially design

Loop Close-out Due Date: TBC	Actual Close-out Date:

Outstanding Issues:

can begin their initial work on the coordinated concrete frame design as long as they have mature 1:50 GA's drawings. Therefore, it is proposed that issue the baseline 1:50's (for early stage co-ordination) to on 3/6/2005, to enable frame detailed design, followed up with more mature 1:50's two weeks after the issue of signed-off 1:50's (8/7/2005).

Ongoing Design Risks:

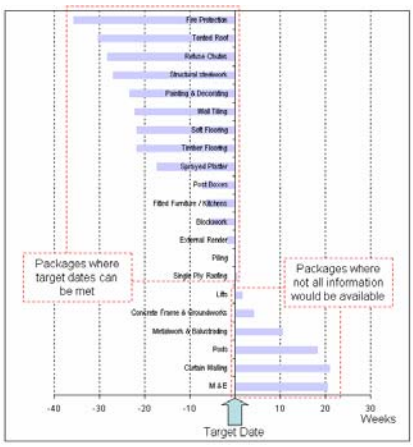
1) Lateness of final baseline 1:50's will delay final coordinated design (high)
2) Major changes to 1:50's post baseline issue (high)
3) Poor coordination due to incomplete 1:50's (high)

This iterative loop has been closed out in accordance with the contract
Signed: Date:
Distribution

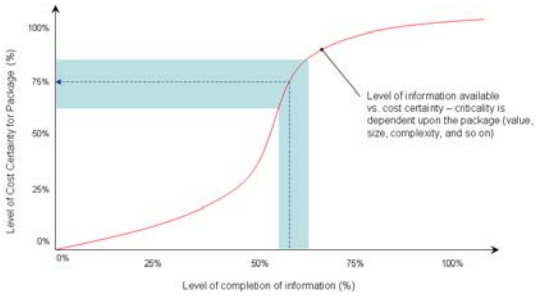
The more significant challenge (and opportunity) lies in defining tactics to manage the design team as they work concurrently on an interdependent design problem. There is no single solution as the number or activities and deliverables, number of team members involved, and time required to develop the design will dictate the most suitable approach. What is important is that each of these issues is thought about in turn and that an appropriate approach is put in place. Recording this in the form of a procedure or method statement focuses the design team on these iterative co-ordination problems and provides a guide for undertaking the work during each period of concurrent working. The figure opposite shows an example of a procedure for the inter-disciplinary design of the interfaces related to a concrete frame.

4.3 Integrating Design with Procurement & Construction

When integrating a design schedule with a construction / procurement schedule, information and document release dates must be tied into dates when those same deliverables are required for tender or construction. Of course this requires a mapping between the design process and the Work Packages which typically give the construction schedule its structure. Rarely does all the required design information meet with the target construction dates, particularly around the early elements of construction. In these cases, design must be expedited through the introduction of assumptions and by fixing information. The assumptions / fixes and their effects can be observed in the matrix stage in ADePT to ensure that only the necessary ones are made. Just as important is that these decisions are made collectively, not unilaterally or left implicit by one party.



Where required design information does not meet with target tender dates, it is not always necessary to introduce assumptions to ensure that all design information is available. Rather, tender information can be released incomplete and assumptions can be made in the pricing which can then be firmed up later. Analysis such as that shown above allows the procurement team to clearly see: (i) the



remaining time required achieving 100% complete design information; (ii) the completeness of information on the target tender date; and (iii) an indication of cost certainty based on that level of completeness. Of course it is important to understand which information is missing and the impact of this upon achieving adequate cost certainty. However, when this level of understanding is required, supplementary analysis can be introduced to augment the indication given in (iii) above.

4.4 Managing Constraints and Measuring Progress

As described earlier, when managing a design project it is important to understand where the process is deviating from the schedule as a result of constraints so that action can be taken. An output of implementing ADePT are reports on forthcoming activities produced intermittently for each design team member, typically every two weeks. These cover the designers' 'work plans' (activities to be undertaken in the next period) and 'look-ahead schedules' (activities due immediately following the next period), applying to design the 'Last Planner' technique used in construction[3]. The reports, which are in the form of to-do lists, are much easier for the design team to digest than a detailed schedule which may have been changed in fairly subtle ways.

Task Description	Responsibility	Start	Percent Complete	End	Status
Agree Long Bridge Structure	Architect	20/03/2007	0	30/03/2007	Due for Completion in this Period
Upper Ground Floor Building Fabric GA	Architect	08/02/2007	50	21/03/2007	Due for Completion in this Period
Podium Level (1) Building Fabric GA	Architect	08/02/2007	50	21/03/2007	Due for Completion in this Period
Service Trench Layouts, Sections & Details (Inc. Connections To Existing Trenches)	Civil & Structural Engineer	01/03/2007	0	26/03/2007	Due for Completion in this Period
Pile & Pile Cap Rebar Schedules	Civil & Structural Engineer	27/02/2007	20	01/03/2007	Due for Completion in this Period
Establish Movement Joint Requirements	Civil & Structural Engineer	07/03/2007	0	12/03/2007	Due for Completion in this Period
Movement Joint Sizing & Specification	Civil & Structural Engineer	13/03/2007	0	16/03/2007	Due for Completion in this Period
Update Structural Model	Civil & Structural Engineer	01/03/2007	0	06/03/2007	Due for Completion in this Period
Movement Joint Details	Civil & Structural Engineer	19/03/2007	0	29/03/2007	Due for Completion in this Period
Comment On S/C Tower Crane Drawings	Civil & Structural Engineer	15/03/2007	0	28/03/2007	Due for Completion in this Period
Stair Layouts & Sections	Civil & Structural Engineer	21/02/2007	20	22/03/2007	Due for Completion in this Period
Core Internal Concrete Wall Sections	Civil & Structural Engineer	23/03/2007	0	28/03/2007	Due for Completion in this Period
Stair Details	Civil & Structural Engineer	21/02/2007	20	12/03/2007	Due for Completion in this Period

Designers are asked to identify any forthcoming activities which they are constrained from completing due to lack of resources, incomplete information, and so on. Where these constraints exist, activities are not promoted from the look-ahead schedule to the work plan. This means that in any period the designers are only asked to undertake activities which are free of constraints and which, therefore, they are able to complete without delay. In the meantime, any constraints are removed so that those activities can be completed in the next work plan period.

At the end of each work-plan period (which is the point where constraint-free activities in the look-ahead schedule are promoted to the next period's work plan), the design team report the progress made and the status of any constraints. Progress is reported as '% complete'. Overall progress is generally measured in two ways: (i) the proportion of activities due for completion which are completed ('percentage planned complete'); and (ii) the proportion of activities due to be started which have been ('percentage planned started'). The first of these measures is the most important since it is only upon the completion of a design activity when all of its outputs can be said to be fully co-ordinated and complete. The measure focuses the team upon fully completing activities since a report that all activities are 90% complete scores a PPC of zero. So, the scenario where an activity's progress develops over time by 0, 50, 80, 85, 90, 95% can be replaced by 0, 50, 100%.

Executive Summary - Overall Design KPI Dashboard	Architect	Civil / Structural	M&E	Contractor	Overall
Percentage Planned Complete	100%	82%	66%	45%	89%
Percentage Planned Started	80%	100%	84%	76%	88%
Percentage of Tasks not Completed Replanned	66%	25%	33%	65%	45%

Having reported on progress and on any constraints affecting activities due in the next work plan period, the design schedule can be updated. This then creates the new work plan and look-ahead schedule which is issued to the team and the process starts over.

5. Impacts

There has been a long-held view among advocates of ADePT that it delivers benefits to project teams. Back in 1999 assessments were made within major design consultancies and contractor organisations about the potential savings which varied from 10 to 22.5% of the total design fee and 0.75 to 1.65% of a project's total cost. The judgments made were high-level, based on the experience of the individuals involved and made at a time when there was insufficient evidence from projects to support the views. Since 2000 anecdotal evidence of the impacts of the technique has been gathered. However, this has also been based upon subjective views which may have been influenced by other factors affecting project team performance.

Robust underlying evidence of the overall impacts of ADePT implementations has recently been gathered by a major independent management consultant[4]. Two projects have been examined in detail and senior project representatives have been interviewed in a structured manner. Despite the fact that the two projects were of a different size and nature (being a c£35M retail development and a c£350M healthcare project) and undertaken by different teams, this process has identified largely common areas of impact:

- ADePT identifies and removes "turbulence" from the project process;

- It provides greater certainty of design co-ordination;
- It offers an ability to better prioritise design work;
- It integrates sub-contractor design with consultant design in an effective way;
- Management of design change is more effective than is typically the case;
- Collaboration between design team members is improved;
- Workflow control focuses the team on task completion;
- It fosters a 'self-policing' design team; and
- The relationship between delivery of outputs and design fee is made clearer.

Three stark examples of these impacts which were quantified:

- Design co-ordination - 32 week saving on achieving co-ordinated design in one complex work package;
- Change management - at least 5 man-weeks saved in avoiding the knock-on effect of a change; and
- Design outputs – c£75K saving where design fees were linked to achievement of design outputs.

It is clear from these examples that there are significant benefits to be derived from the implementation of the approach. Of course, these benefits are not derived without any sacrifice on the part of the project team. The team must be prepared to invest in the adoption of a new approach. This means staff time contributing to the design planning process and the costs of expert advice, training and the supporting tools to deploy the technique.

Clearly, even with an investment cost, the returns are significant. Even in just the three examples above there is a return of around 80% over a 9 month detailed design process. With the savings predicted in 1999 the return would be in the order of 5 – 10 times the investment cost in a £30M project with a 9 month design process.

6. Conclusions

Despite increased awareness of the importance of an integrated design process, and some tangible steps toward achieving this goal by the industry, projects often continue to be delivered late and over budget.

The analytical design planning technique (ADePT) offers an approach to planning and controlling design processes which is more effective than is typical in current practice. Practical implementation involves a structured, facilitated approach but this provides opportunities to establish the optimal sequence of the process and to understand the interface between design and construction. The workflow stage enables the design process to be monitored and controlled effectively.

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